PROJECT : A NOVEL METHOD FOR HANDWRITTEN DIGIT RECOGNITION SYSTEM

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ABSTRACT

Character recognition plays an important role in the modern world. It can solve more complex problems and makes humans' job easier. An example is handwritten character recognition. This is a system widely used in the world to recognize zip code or postal code for mail sorting.

There are different techniques that can be used to recognize handwritten characters. Two techniques researched in this paper are Pattern Recognition and Artificial Neural Network (ANN). Both techniques are defined and different methods for each technique is also discussed.

Bayesian Decision theory, Nearest Neighbor rule, and Linear Classification or Discrimination is types of methods for Pattern Recognition. Shape recognition, Chinese Character and Handwritten Digit recognition uses Neural Network to recognize them. Neural Network is used to train and identify written digits. After training and testing, the accuracy rate reached 99%. This accuracy rate is very high.

Character recognition is becoming more and more important in the modern world. It helps humans ease their jobs and solve more complex problems. An example is handwritten character recognition which is widely used in the world.

This system is developed for zipcode or postal code recognition that can be employed in mail sorting. This can help humans to sort mails with postal codes that are difficult to identify. For more than thirty years, researchers have been working on handwriting recognition.

Over the past few years, the number of companies involved in research on handwriting recognition has continually increased. The advance of handwriting processing results from a combination of various elements, for example: improvements in the recognition rates, the use of complex systems to integrate various kinds of information, and new technologies such as high quality high speed scanners and cheaper and more powerful CPUs.

Some handwriting recognition system allows us to input our handwriting into the system. This can be done either by controlling a mouse or using a third-party drawing tablet.

The input can be converted into typed text or can be left as an "ink object" in our own handwriting. We can also enter the text we would like the system to recognize into any Microsoft Office program file by typing. We can do this by typing 1s and 0s.

This works as a Boolean variable. Handwriting recognition [4] is not a new technology, but it has not gained public attention until recently. The ultimate goal of designing a handwriting recognition system with an accuracy rate of 100% is quite illusionary, because even human beings are not able to recognize every handwritten text without any doubt. For example, most people can not even read their own notes. Therefore there is an obligation for a writer to write clearly.

In this, both Pattern Recognition and Neural Networks will be defined. Examples of types of Pattern Recognition and Neural Networks will be discussed. The advantages of using Neural Networks to recognize handwritten characters will be listed.

Finally, Artificial Neural Networks, using back-Propagation method will be used to train and identify handwritten digits.

PATTERN RECOGNITION :

 What is Pattern Recognition -

Pattern recognition system consists of two-stage process. The first stage is feature extraction and the second stage is classification. Feature extraction is the measurement on a population of entities that will be classified.

This assists the classification stage by looking for features that allows fairly easy to distinguish between the different classes. Several different features have to be used for classification. The set of features that are used makes up a feature vector, which represents each member of the population.

Then, Pattern recognition system classifies each member of the population on the basis of information contained in the feature vector.

Pattern recognition methods -

Bayesian decision theory. The Bayesian decision theory is a system that minimizes the classification error. This theory plays a role of a prioi. This is when there is priority information about something that we would like to classify.

What the formula means is that using a priori information, we can calculate the a posteriori probability of the state of nature being in state w hat we have given that the feature value x has been measured.

So, if we observe a certain x for a random fruit in the conveyer belt, then by calculating P(wapp/x) and P(worg /x). we would decide that the fruit is apple if the first value is greater than the second one and if P(worg/x) is org greater, then we would decide that the fruit is orange.

Linear Classification Discrimination –

The goal of Linear Classification is to assign observations into the classes. This can be used to establish a classifier rule so that it can assign a new observation into a class. In another words, the rule deals with assigning a new point in a vector space to a class separated by a boundary.

Linear classification provides a mathematical formula to predict a binary result. This result is a true or false (positive or negative) result or it can be any other pair of characters. In general, we will assume that our Results are Boolean variable. To do this prediction, we use a linear formula over the given input data.

We refer this as inputs. The linear form is computed over the inputs and the result is compared against a basis constant. It is depending on the result of the comparison that we would be able to predict true or false.

HANDWRITTEN CHARACTER RECOGNITION IN PATTERN RECOGNITION –

Linear Classification [9] is a useful method to recognize handwritten characters.[4] The background basis of Artificial Neural Network (ANN)[2] can be implemented as a classification function. Linear Classification works very similar to Artificial Neural Network because the mapping of the ANN cell or one layer of the ANN cell is equivalent to the linear discrimination function.

Therefore, if the ANN is a two-layer network, which is consisting of an input and an output layer, it can act as a linear classifier.

What is Neural Network –

A Neural Network (NN) is a function with adjustable or tunable parameters. Let the input to a neural network be denoted by x. This is a real-valued or row vector of length and is typically referred to as input or input vector or regressor or sometimes pattern vector.

The length of the vector x is the number of inputs to the network. So let the network output be denoted b Y. This is an approximation of the desired output y, which is also a real-valued vector having one or more components and the number of outputs from the network.

The data sets often contain many input and output Malothu Nagu et al, / (IJCSIT) International Journal of Computer Science and Information Technologies, Vol. 2 (4) , 2011, 1685-1692 1687 pairs. The x and y denote matrices with one input and one output vector on each row.

 A neural network[2] is a structure involving weighted interconnections between neurons or units. They are often non-linear scalar transformations but can also be linear scalar transformation.

A neuron is structured to process multiple inputs. This includes the unity bias in a non-linear way. Then, this produces a single output. All inputs to the neuron are first augmented by multiplicative weights.

These weighted inputs are summed and then transformed via a non-linear activation function and as indicated. The single output neuron is linear because no activation function is used. The information in an ANN is always stored in a number of parameters. These parameters can be pre-set by the operator or trained by presenting the ANN with example.

Artificial Neural Network –

Artificial Neural Network (ANN) has been around since the late 1950's. But it Was not until the mid-1980 that they became sophisticated enough for applications. Today, ANN is applied to a lot of real-world problems.

These problems are considered complex problems. ANN's are also a good pattern recognition engines and robust classifiers. They have the ability to generalize by making decisions about imprecise input data. They also offer solutions to a variety of classification problems such as speech, character and signal recognition.

Artificial Neural Network (ANN) is a collection of very simple and massively interconnected cells. The cells are arranged in a way that each cell derives its input from one or more other cells. It is linked through weighted connections to one or more other cells. This way, input to the ANN is distributed throughout the network so that an output is in the form of one or more activated cells.

Multi-Layer Feed-forward Neural Networks :

Multi-Layer Feed-forward neural networks (FFNN) have high performances in input and output function approximation. In a three-layer FFNN, the first layer connects the input variables. This layer is called the input layer. The last layer connects the output variables.

This layer is called output layer. Layers between the input and output layers are called hidden layers. In a system, there can be more than one hidden layer. The processing unit elements are called nodes. Each of these nodes is connected to the nodes of neighboring layers.

The parameters associated with node connections are called weights. All connections are feed forward; therefore they allow information transfer from previous layer to the next consecutive layers only. For example, the node j receives incoming signals from node i in the previous layer.

Each incoming signal is a weight. The effective incoming signal to node j is the weighted sum of all incoming signals.

Back-propagation algorithm -

Back-propagation algorithm consists of two phases. First phase is the forward phase. This is the phase where the activations propagate from the input layer to the output layer. The second phase is the backward phase.

This is the phase where then the observed actual value and the requested nominal value in the output layer are propagated backwards so it can modify the weights and bias values.

In forward propagation, the weights of the needed receptive connections of neuron j are in one row of the weight matrix. In backward propagation, the neuron j in the output layer calculates the error between the expected nominal targets.

The error is propagated backwards to the previous hidden layer and the neuron i in the hidden layer calculates this error that is propagated backwards to its previous layer. This is why the column of the weight matrix is used. n the actual output values.

This output value is known from both the forward propagation and backward propagation.

Handwritten Character Recognition –

There are many different types of recognitions in the modern time, which can really solve complex problems in the real world today. Examples of recognitions are: face recognition, shape recognition, handwritten character recognition, such as handwritten Chinese character recognition and handwritten digit recognition.

Shape Recognition –

Shape describes a spatial region. Most shapes are a 2-D space. Shape recognition works on the similarity measure so that it can determine that two shapes correspond to each other. The recognition needs to respect the properties of imperfect perception.

For example: noise, rotation, shearing, etc. One of the techniques used in shape recognition is elastic matching distance. Here we use a binary-valued image X on the square lattice S as an example. The value of X at pixel belonging to S is denoted X(s).

The images we are interested in this example are the images of the handwritten numerals. Pixel with value 1 stands for "black' or "numeral' and pixel with value 0 stands for "white' or "background'. There are ten numeral classes numbered 0 to 9.

These ten numeral classes come in different shapes. The goal is to provide a space of images on S with an alternative metric (X, X') that can reduce this intra-class spread as much as possible. Matching problems are not easy tasks. Satisfactory matches can sometimes be obtained reliably and rapidly under two general conditions:

 1. Objects to be matched should be topologically structured.

 2. Initial conditions should provide a rough guess of the map to be constructed.

Chinese Character Recognition –

Recognition of similar characters (or confusion characters) is a difficult task. An example of similar characters is Chinese characters. Chinese characters have a wide range of complexity. The characters may consist of one to thirty or more distinct strokes.

The differences between characters can be quite small. One of the techniques that can be used to recognize handwritten Chinese characters is using Optical Character Recognition (OCR). Here, OCR uses probabilistic neural network to recognize Chinese characters.

 The training of the classifier starts with using the distortionmodeled characters from four fonts. Statistical measures are taken the set of features computed from the distorted character. Based on these measures, the space of feature vectors is transformed to the optimal discriminant space for nearest neighbor classifier.

 In the discriminant space, a probabilistic neural network classifier is trained. For classification, the modifications are presented to the standard approach by implying the probabilistic neural network structure. The approach is compared using discriminant analysis and Geva and Sitte's Decision Surface Mapping classifiers. All methods are tested using 39,644 characters in three different fonts.

NEURAL NETWORK BASED HANDWRITTEN DIGIT RECOGNITION –

Artificial Neural Network system is used to recognize ten different handwritten digits. These are digits from zero to nine. Here, back-propagation neural network is used to train all the data. The major problem is the digits are handwritten; therefore it is subject to enormous variability.

Digits were written by different people, using a great variety of sizes, styles, and instruments. Back-propagation can be applied to real image recognition problems without a complex pre-processing stage, which requires a detailed engineering.

The learning network is fed directly with images rather than feature vectors. Before inputting the data into the network, the image has to be closed first so there would have no minor holes. Then the image is resized to 16 X 16 pixels. Afterwards, the image is thinned so only the skeleton remains.

When the skeleton image is obtained, the horizontal, vertical, right diagonal, and left diagonal histogram of the image is determined. Then the histograms are concatenated into one large integer sequence. The integer sequence is the digit representation [6]. This is fed into the neural network. A three-layered neural network issued. This is 94 input units, 15 hidden units, and 10 output units.

Neural Network Digit Recognition System –

 In order to have a learning task that is reasonably workable, a great amount of pre-processing of the digits is carried out using conventional Artificial Intelligence (AI) techniques. This is done before the digits are fed to the ANN. The difficult task is there are some handwritten digits that often run together or not fully connected.

Numeral 5 is an example. But once these tasks have been carried out, the digits are available as individual items. But the digits are still in different sizes. Therefore a normalization step has to be performed so we can have to have digits in equal sizes. After the digits are normalized, they are fed into the ANN. This is a feed-forward network with three hidden layers.

The input is a 16 x 16 array that corresponds to the size of a normalized pixel image. The first hidden layer contains 12 groups of units with 64 units per group. Each unit in the group is connected to a 5 x 5 square in the input array and all 64 units in the group have the same 25 weight values. The second hidden layer consists of 12 groups of 16 units.

This layer operates very similar to the first hidden layer, but now it seeks features in the first hidden layer. The third hidden layer consists of 30 units that are fully connected to the units in the previous layer. The output units are in turn fully connected to the third hidden layer.

ADVANTAGES –

This approach has many advantages :

1) The system not only produces a classification of the digit but also a rich description of the instantiation parameters which can yield information such as the writing style.

2) The generative models can perform recognition driven segmentation.

3) The method involves a relatively small number of parameters and hence training is relatively easy and fast and

4) Unlike many other recognition schemes, it does not rely on some form of pre-normalization of input images, but can handle arbitrary scalings, translations and a limited degree of image rotation.

We have demonstrated that our method of fitting models to images does not get trapped in poor local minima. The main disadvantage of the method is that it requires much more computation than more standard OCR techniques.

5) Recently handwritten digit recognition becomes vital scope and it is appealing many researchers because of its using in variety of **machine learning and computer vision applications**. However, there are deficient works accomplished on Arabic pattern digits because Arabic digits are more challenging than English patterns.

DISADVANTAGES –

1) The main disadvantage of the method is that **it requires much more computation than more standard OCR techniques**.

2) The disadvantage is that **it is not done in real time as a person writes and therefore not appropriate for immediate text input**. Applications of offline handwriting recognition are numerous: reading postal addresses, bank check amounts, and forms.